Urban Landuse and Transportation Planning
Prof.Debapratim Pandit
Department of Architecture & Regional Planning
Indian Institute of Technology – Kharagpur

Lecture - 46
Transportation Software

Welcome back. In module 10, transportation demand modeling using software will be covered. In this lecture, we will start with general transportation software.

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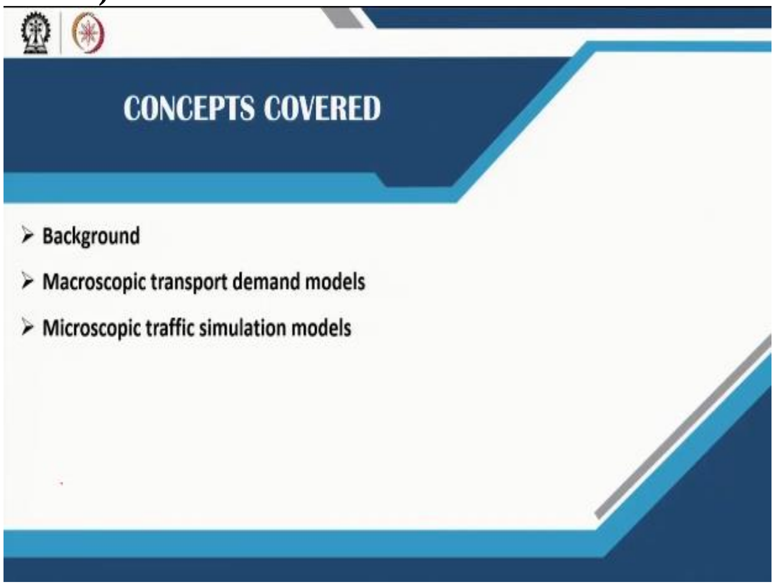

Background of transportation software, macroscopic transportation demand models and microscopic traffic simulation models will be covered in this lecture.

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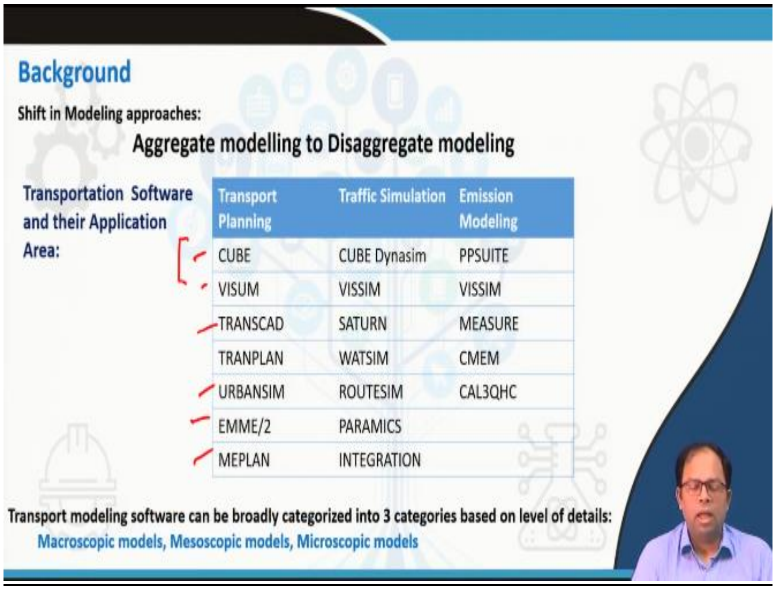

Background:

With the shift of transportation modelling from aggregate to disaggregate modeling, the data requirement has increased tremendously. The huge amount of data corresponds to the trips of different groups of people, belonging to different socio economic backgrounds, then, the trip distribution and assignment based on different modes. Handling such data can be managed manually for few zones, however, it is very difficult for an individual to do all the model stages for a larger area or a region. Transportation software enables planners and modelers to handle large areas. Corresponding to the required level of details, macroscopic models, mesoscopic models or microscopic models can be employed. These models vary in the data required to be input to the model, ie, if a macroscopic model has to be developed, there is no need to put in intersection geometry for the links in that particular model, similarly, macroscopic model and mesoscopic models will also require a different set of data.

Transportation modelling software is broadly divided into 3 kinds:

- **Macroscopic models**
- **Mesoscopic models**
- **Microscopic models**

However, most of the commercial software available can handle all these three kind of models. Some of the commercial and widely used software available includes CUBE and VISUM.

These are further categorized under 3 categories based on their application area such as transportation planning, traffic simulation and emission modelling. Transport planning refers to overall travel demand management including freight management whereas, traffic simulation relates to a microscopic level study. Traffic simulation involves movement of vehicles in each corridor, the kind of effects it creates at different times of the day, congestion, queues generated etc. The different application areas are served by the different components of the transportation software mentioned. Emission modelling can also be done using the software based on traffic flow.Most of these models have a specific component corresponding to the different application area. CUBE Dynasim and PPSUITE are the components of the software corresponding to traffic simulation and emission modelling for CUBE whereas VISUM has got VISSIM for the traffic simulation component as well as the emission modelling. URBANSIM, MEPLAN, TRANSCAD, EMME/2 are other such software models which are popularly used all over the world. URBANSIM has ROUTE SIM as the traffic simulation component and CAL3QHC is the emission modelling component.

In this lecture, CUBE and VISUM will be addressed because these are commercial level software. These are robust but at the same time, the amount of calibration that could be done is limited. However, with the different kinds of components, it can handle a large amount of data to run the different models.

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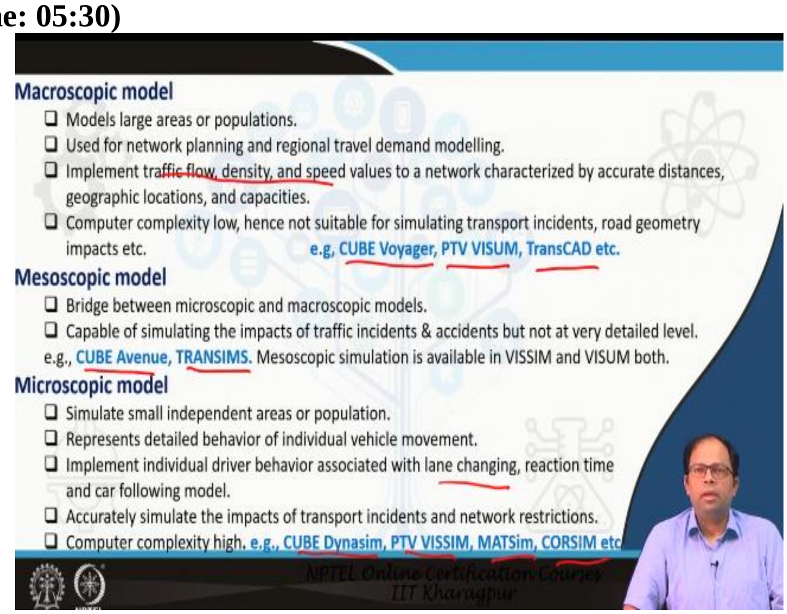

Macroscopic models:

Macroscopic models are for larger areas or for big groups of population. These are primarily used for either 4 stage model or for generating activity based model for an urban area; which are different approaches for travel demand modeling. In order to address the supply part of transportation, there are traffic assignment models which assigns the demand to the different networks and creates a feedback from the network which again influences the demand. It can handle large areas in forms of zones or TAZs as well as model the entire network. It can be used for network planning as well as for regional level travel demand modelling. These models can implement traffic flow, density and speed values to a network characterized by accurate distances, geographic locations, and capacities once the network is built. Macroscopic model cannot do the simulation of the traffic signals as well as the dynamic traffic assignment. Link cost function will be considered by these models. Traffic flow density, speed becomes the parameters which are associated with the network. The computational requirement for these models is low and hence simulation of transport incidents, road geometry impacts etc. is difficult.

Examples include CUBE Voyager, which is the component in CUBE which can handle the 4 stage model, tour based model or activity based travel demand models. Similarly, PTV VISUM and TRANSCAD are the other examples which can handle these kind of models.

Mesoscopic models:

Mesoscopic models form a bridge between the microscopic and macroscopic models. These are capable of doing dynamic traffic assignment. It is capable of simulating the impacts of traffic incidents and accidents but not at a very detailed level. Microscopic model addresses such detail that is, it can simulate the queue lines, the situation in that particular queue etc. Every vehicle could be modelled in a microscopic simulation but in a mesoscopic model, it cannot be done, but at the same time, the total amount of signal time, the turn volumes, the total amount of queue lines etc. can be done at the mesoscopic level also. It is possible to run a dynamic assignment model, if there is a microscopic model along with macroscopic model, however, microcopic models are very data intensive and takes a lot of time to simulate traffic for a particular area. So, it cannot be applied to the entire city at one go and has to be done for the different small zones separately. Mesoscopic model helps in getting the details which is required for dynamic traffic assignment such as how the queues increase with increasing amount of vehicle coming into the link, how the queue dissipates in the link when the total amount of vehicles falls and how the queue gets moved to the next link or how the conjestion spills over to the next link. Thus, it is capable of simulating impacts of traffic incidents and accidents but not at very detailed level based on certain impedence parameters considered.

CUBE Avenue and TRANSIMS are 2 examples of mesoscopic models. Mesoscopic simulation is available in both VISSIM and VISUM.

Microscopic models:

Using microscopic models, small independent areas of population can be simulated rather than a large area or city such as a CBD or an area within the CBD limit. Here, detailed behavior of individual vehicle movements can be represented such as how a vehicle is getting inside the link; an arrival function is used for this and it could be explained using various mathematical functions such as an exponential distribution, normal distribution etc. Thus, the arrival rate of each vehicle in a particular link is understood and simulation of flow can be done. Individual driver behavior associated with lane changing, reaction time and the car following model can also be implemented. So, how a vehicle follows another vehicle, change from one lane to another, the rules followed, etc can be modelled. All these components when simulated for certain time intervals which could be discrete or continuous helps in determining the flow situation in a particular link. Simulation is done because it is very difficult to model all this behavior using mathematical equations. When simulations are implemented, interaction between the vehicles and that between a vehicle and different road geometry are captured and the solution is determined. It accurately simulates the impact of transport incidents and network restrictions. Computer complexity is however high.

Different simulation softwares that are used includes CUBE Dynamism, PTV VISSIM, MATSim, CORSIM etc.

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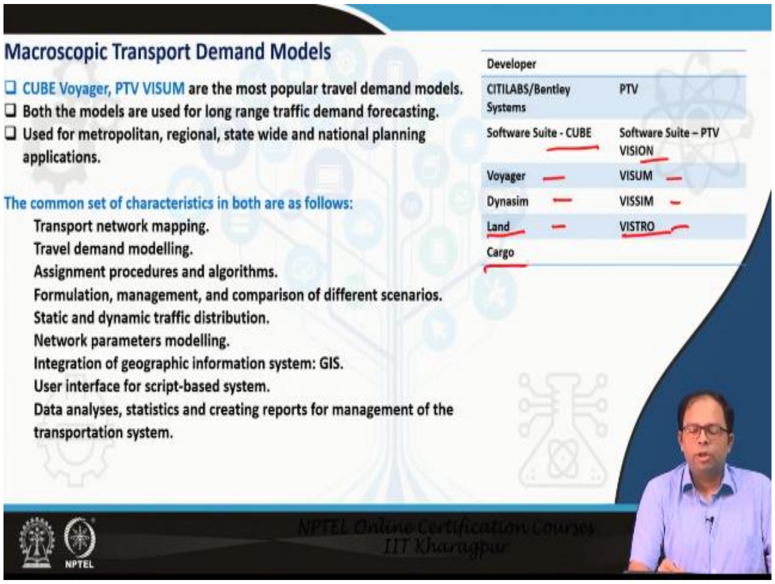

<u>Macroscopic travel demand models:</u>

CUBE Voyager and PTV VISUM are the most popular travel demand models commercially available. CUBE Voyager comes with the CUBE base which helps to design the networks whereas PTV VISUM does not have a separate platform for designing the network. Network preparation is inbuilt and part of PTV VISUM itself. The road networks prepared in CUBE base is then used for CUBE voyager to implement the travel demand modelling. Both the software are useful for long range traffic demand forecasting. It is useful at different scales of application with respect to the area extent. It could be used for metropolitan, regional, statewide and national planning applications.

The common set of characteristics in CUBE Voyager and PTV VISUM:

Transport network mapping – This involves mapping of all the roads links, nodes, connectors between different links, restricted and unrestricted flows, the transit network etc.

Travel demand modelling – Aggregate models and desegregate models can be done. Both 4 stage model or an activity based model can be done.

Assignment procedures using different algorithm – This is the next stage after the demand modelling. There is support for different kinds of assignment.

Formulation, management and comparison of different scenarios – This is a very useful application of these software because different scenarios can be modelled very fast once the basic model is done. Based on this, different policies can be adopted or rejected. For example, such models can be used to assess the impact of odd-even rule for passenger transport on pollution level when the pollution level exceeded in many parts of the country. Similarly, it can be used to understand the impact of when two way movement is converted to one way on a road or the impact of parking restriction in a particular locality etc. The feedback generated by the software becomes very useful and changes can be made on its basis.

Data analysis, statistics, and creating reports for management of the transportation system – Data analysis is done and reports are generated for the management based on which decision makers can decide.

Static and dynamic traffic distribution – both can be modelled.

Network parameters modelling

Integration of geographic information system: GIS

User interface for script-based system – The standard models that are there in the system can be used directly however, if it is needed to calibrate those models, it would call for modification of the model equation or the models itself. Scripts prove to be useful to avoid this situation. Scripts are smaller programs that are written in a common language like a python script or something which is very custom for that particular software. Accordingly, the existing model structure gets updated before it is run.

Comparison between CUBE Voyager and PTV VISUM:

CUBE and PTV VISION are the software suites. Voyager and Dynasim are the ones supporting macroscopic and microscopic models respectively for CUBE whereas VISUM and VISSIM are the ones corresponding to that of PTV VISUM.

CUBE Land and VISTRO supports the land use component for CUBE Voyager and PTV VISUM respectively. This component corresponds to the real estate development, changes in land use etc. CUBE cargo is used for modelling freight transport.

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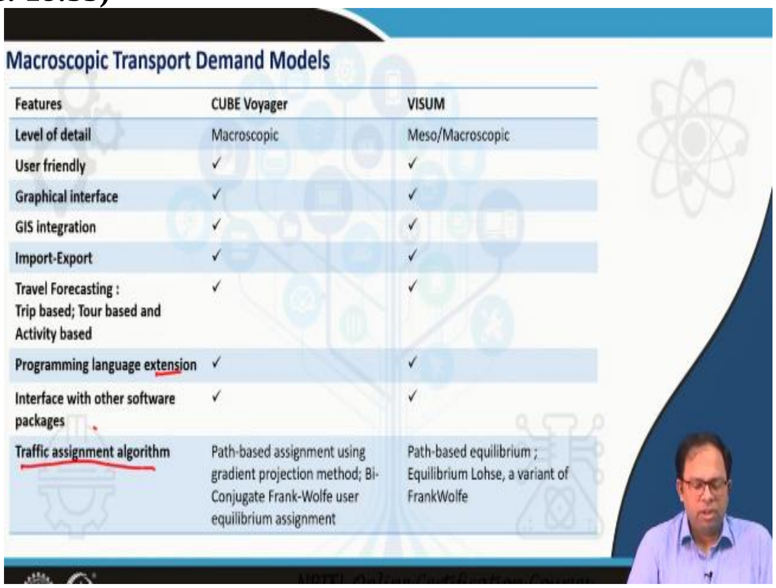

CUBE Voyager supports macroscopic models whereas VISUM supports both mesoscopic and macroscopic models. Both of them has a user friendly interface and is integrated with GIS and allow import and export of data easily. Both can implement travel forecasting based on trips, tours as well as following activity based modeling. Activity based modelling will be addressed in detail in the final module. It is also possible to have programming language extensions in both and these are referred to as scripts. Traffic assignment has also slight changes between CUBE Voyager and VISUM. CUBE Voyager does path-based assignment using radiant projection method; BI-conjugate Frank-Wolfe equilibrium assignment is undertaken. In VISUM path based equilibrium; Equilibrium Lohse and a variant of FrankWolfe is actually utilized.

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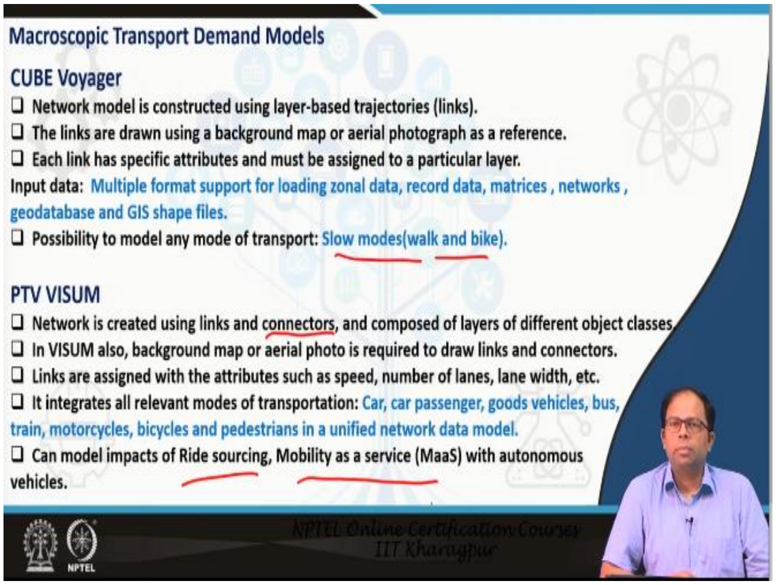

Macroscopic travel demand models using Cube Voyager:

In CUBE Voyager, the network model is constructed using different layer-based trajectories or links and these links are drawn using a background map or aerial photograph as a reference; background map can be imported and the links can be drawn over that. Then, the links can be modified and adjusted and specific attributes can be updated and must be assigned to a particular layer. Different formats of input data are supported for loading zonal data, record data, matrices, networks, geodatabase and GIS shape files. Any mode of transport can be modeled including the slow modes such as walking and bicycling, though, these were not supported earlier.

Macroscopic travel demand models using PTV VISUM:

Network is created using links and connectors and composed of layers of different object classes. This helps in connecting the links and to represent the different turns allowed. Each kind of item is a class similar to programming. In VISUM also, background map or aerial photograph is required to draw links and connectors same as CUBE Voyager and links are assigned with the attributes such as speed, number of lanes, lane width etc. It integrates all relevant modes of transportation; cars, car passengers, goods vehicles, bus, train, motorcycles, bicycles and pedestrian in a unified network data model. Another new feature in PTV VISUM is that they can model ride sourcing services and mobility as a service (MaaS) with autonomous vehicles as well.

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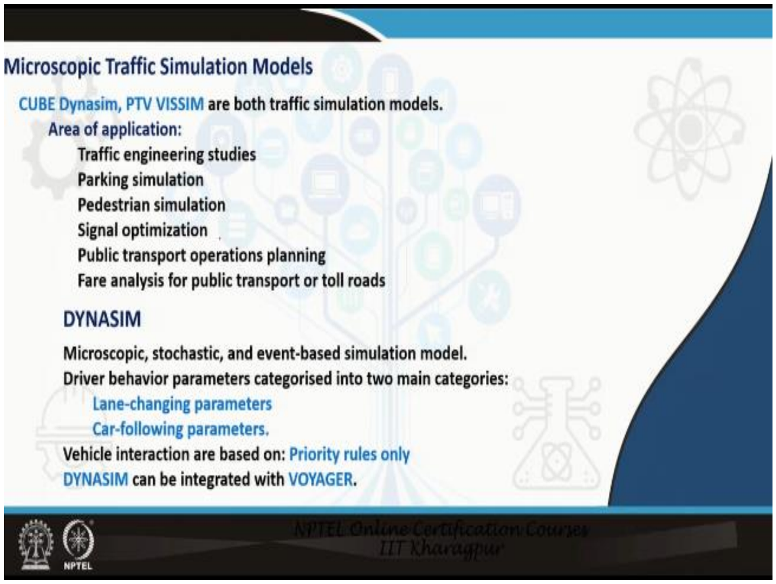

Microscopic travel demand models:

Unlike macroscopic and mesoscopic models, microscopic traffic simulation models are used for microscopic traffic modelling. For example, it can be used to model different traffic geometries such that the impact of certain kind of traffic signal systems can be understood. CUBE Dynasim and PTV VISSIM are both traffic simulation models from the CUBE and PTV group respectively

Area of application:

Traffic engineering studies

Parking simulation studies

Pedestrian simulation studies - Example: when a game ends in a large facility like a stadium, how the people are going to come out, where they would go, and how they would gather at different transit stops etc. could be modelled.

Signal optimization

Public transport operations planning and

Fare analysis for public transport or toll roads. All these can be modelled using microscopic traffic simulation.

Microscopic traffic simulation using DYNASIM:

It is a microscopic, stochastic and event based simulation model. Stochastic model implies that effect of an event can be found using a probabilistic approach. Driver behavior parameters are categorized into 2 main categories:

- Lane changing parameters and
- Car following parameters.

As explained earlier, when a car is introduced into a particular link, it is done based on an arrival function, that is, the movement of the car gets initiated and after that, there is car following and lane changing which involves the lateral movement of cars on either sides; which needs to be modelled. A certain set of rules has to be followed to model such behavior. DYNASIM can also be integrated with Voyager.

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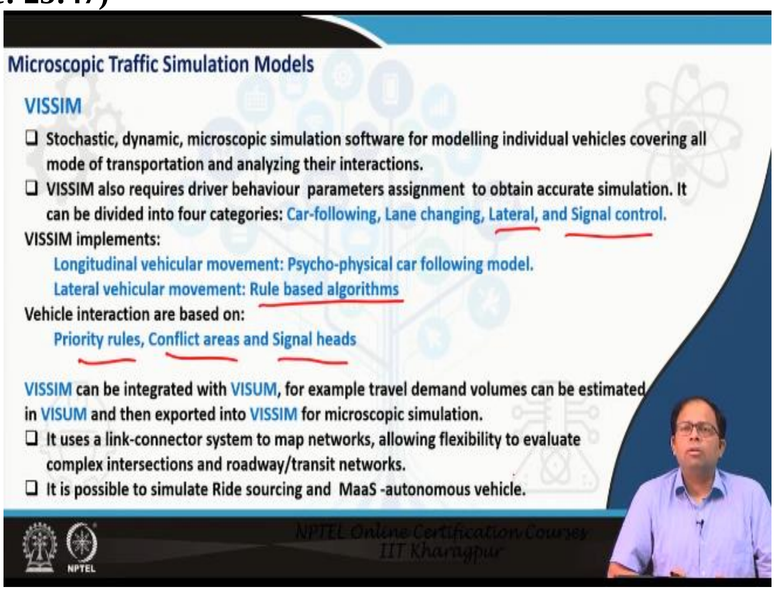

Microscopic traffic simulation using VISSIM:

It is also stochastic, dynamic, microscopic simulation software which covers all modes of transportation and also analyses their interaction. VISSIM also requires driver behavior parameters assignment to obtain accurate simulation. It could be divided into 4 categories:

- Car following behavior
- Lane changing behavior

- Lateral movement behaviour
- Signal control

VISSIM can implement longitudinal vehicular movement using psycho-physical car following model i.e., not only the physical characteristics such as acceleration, speed, distance are considered but the driver behavioral part is also modelled. Lateral vehicular movement is based on rule based algorithms. Vehicle interactions are based on priority rules, conflict areas and signal heads. So these are 3 different ways the vehicles interact at different situations.

VISSIM can be integrated with VISSUM. For example, travel demand volumes can be estimated in VISUM, and then can be exported to VISSIM for microscopic simulation.

So, once the overall travel demand estimate is done, the effect in certain smaller areas are modeled because very large areas cannot be considered. This uses a link connector system to map networks allowing flexibility to evaluate complex intersections and roadway and transit networks. So as explained earlier, there is another parameter called connectors apart from the links and nodes which gives the different turning volumes, the proportion of vehicles in different turns etc. So this allows complex interactions getting modelled for a particular intersection or for networks. It is also possible to simulate ride sourcing and MaaS-autonomous vehicles.

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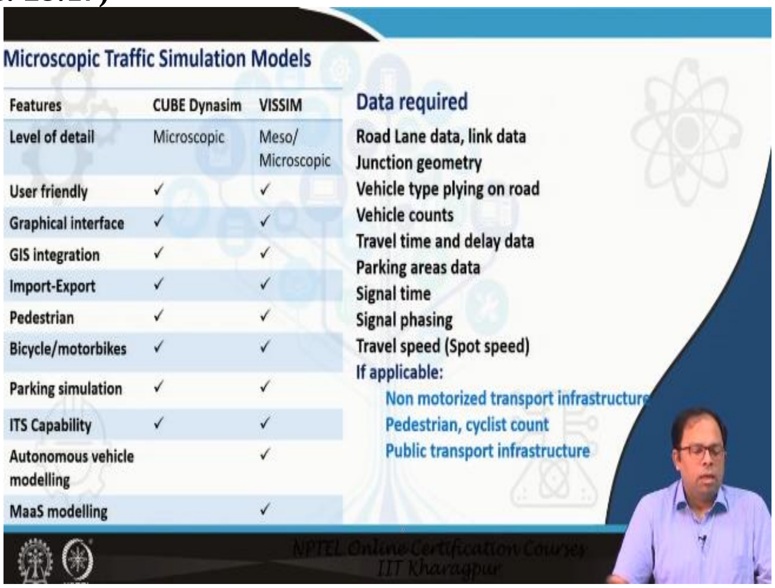

Comparison between CUBE Dynasim and VISSIM:

Both show similar amount of capabilities. Level of detail is microscopic for DYNASIM whereas its either mesoscopic or microscopic for VISSIM. Both are user friendly and has a good graphical interface. GIS integration is possible for both. Both allows modelling of pedestrian movement and that of bicycle and motorbikes. Parking simulation could also be done in both. ITS is inbuilt for both. Autonomous vehicle modelling and MaaS modelling is supported only for VISSIM.

Data required for microscopic traffic simulation models:

Data required involves road lane data, link data, junction geometry, vehicle types plying on the road and their distribution, vehicle counts, travel time and delay data, parking areas data, signal time, signal phasing which could also be based on simulation, travel speed etc. If applicable, non-motorized transport infrastructure, pedestrian, cyclist count, public transport infrastructure has to be input into the data set.

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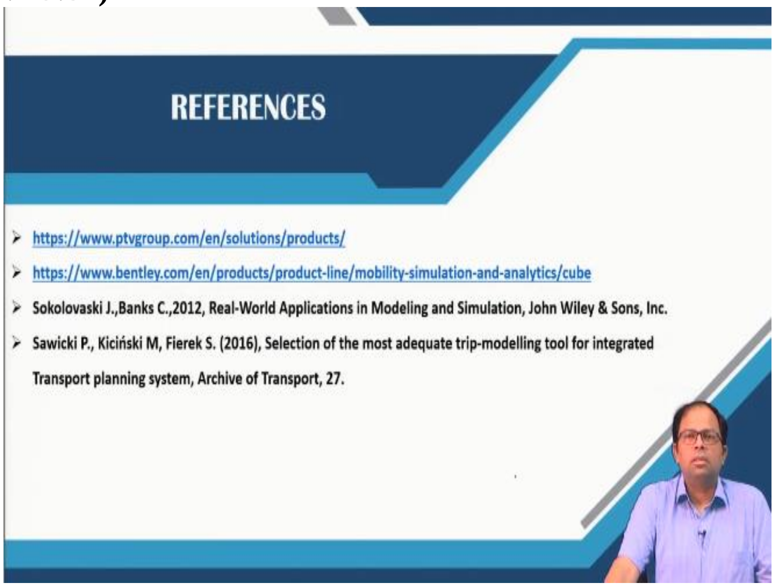

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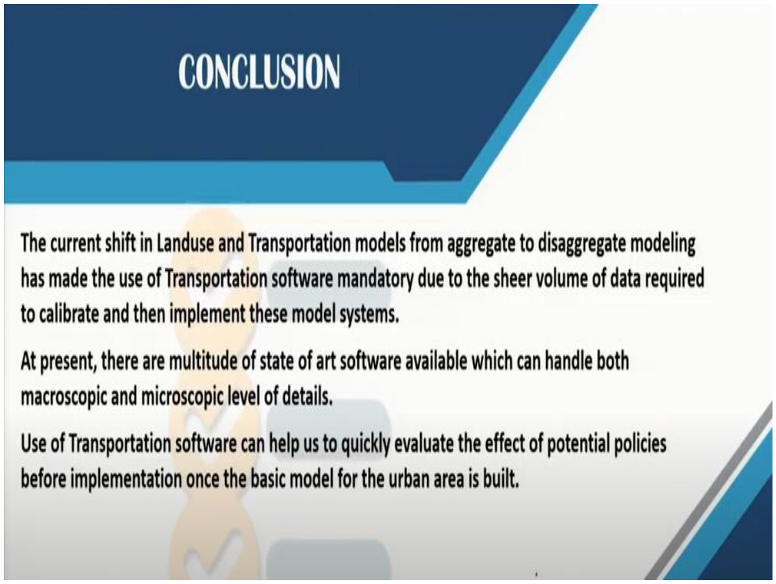

The given references can be used.

<u>Conclusion:</u>

- The current shift in Landuse transportation models from aggregate to disaggregate modelling has made the use of transportation software mandatory due to the sheer volume of data required to calibrate and then implement this model systems.
- At present, there are multitude of state of art softwares available which can handle both macroscopic and microscopic level of details.
- Use of transportation software can help us to quickly evaluate the effect of potential policies before implementation once the basic model for urban area is built.

In the next lecture, details about the CUBE software and the different components of CUBE software can be explored. Thank you.